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How long does it take to find a cause ?  
An on-line investigation of implicit causality in sentence production

Michèle Guerry  
Laboratoire Langage et Cognition (LACO),  
CNRS FRE 2725  
Université de Poitiers

Manuel Gimenes  
LACO  
Université de Poitiers

David Caplan  
Massachusetts General Hospital

and

François Rigalleau  
LACO  
Université de Poitiers

Address correspondence to:  
Michèle Guerry  
Laboratoire Langage et Cognition,  
CNRS, FRE 2725  
99 avenue du Recteur Pineau,  
F-86022 POITIERS, FRANCE  
Tel: +33 (0)5 49 45 46 34  
Fax: +33 (0)5 49 45 46 16  
e-mail: michele.guerry@mshs.univ-poitiers.fr

(This version had several minor modifications in the final version)

### Abstract

Some interpersonal verbs show an implicit causality bias in favor of their subject or their object. Such a bias is generally seen in off-line continuation tasks where participants are required to finish a fragment containing the verb (e.g., Peter annoyed Jane because ...). The implicit causality bias has been ascribed to the subject's focusing on the initiator of the event denoted by the verb. According to this "Focusing theory" the implicit cause has a higher level of activation, at least after the connective "because" has been read. Recently, the Focusing theory has been criticized by researchers who used a probe recognition or reading time methodology. However no clear alternative has been proposed to explain the off-line continuation data. In this paper, we report three experiments using an on-line continuation task which showed that subjects took more time to imagine an ending when the fragment to be completed contained an anaphor that was incongruent with the verbal bias (e.g. Peter annoyed Jane because she ...). This result suggests that the off-line continuation data could reflect the cognitive effort associated with finding a predicate with an agent incongruent with the implicit causality bias of a verb. In the discussion, we suggest that this effort could be related to the number of constraints that an incongruent clause must satisfy to be consistent with the causal structure of the discourse.

## How long does it take to find a cause ?

### An on-line investigation of implicit causality in sentence production

#### Introduction

Assigning a cause to an event can depend on the way this event is described. For instance, when we consider sentence (1), we generally assume that the cause of the disappointment is the attitude or the behavior of John, the first participant in the sentence.

(1) John disappointed Bill because he ...

Conversely, for sentence (2), the cause of the admiration is generally assigned to the second participant Bill.

(2) John admired Bill because he ...

Garvey and Carmazza (1974) were the first authors who noticed that many verbs show a strong causality bias towards their subject or their object. Using a continuation task, Garvey, Carmazza and Yates (1975) showed that the continuations of (1) and (2) were generally consistent with the assignment of the implicit cause to the ambiguous pronoun. Of course, in continuation studies, the fact that the implicit cause of some verbs is either the subject or the object emerges as a "bias" and generally not as an all or none phenomenon. For instance, Au (1986) tested 48 verbs and found that some verbs like "disappoint" show a bias of 80% in favor of their subject. Some subjects can find a way to assign the cause to the other noun as in (3).

(3) John disappointed Bill because he set himself up for disappointment.

This sort of continuation is said to be incongruent with the bias of the verb if a majority of subjects prefer to assign the cause to the other noun.

The implicit causality of verbs is not only revealed by continuation data. Some on-line comprehension experiments have shown that implicit causality bias has effects on the reading time of the causal clause, or on the level of activation of the cause.

Caramazza, Grober, and Yates (1977) presented sentences like (4) and (5). The subjects had to say the name of the pronoun referent, and response times were measured.

(4) Tom scolded Bill because he was annoying.

(5) Tom scolded Bill because he was annoyed.

They found longer response times when the ending was not congruent. Using the same method, Ehrlich (1980) confirmed that the choice of the referent was influenced by the causality relation denoted by the connective "because": another connective like "but" elicited different answers.

Many other studies found the same type of result when the reading time of the causal clause was measured (e.g. Garnham, Oakhill, & Cruttenden, 1992; Stewart, Pickering, & Sanford, 2000; Rigalleau, Caplan, & Baudiffier, 2004). Garnham et al. (1992) showed that the effect of congruity tended to be stronger when the inference needed to connect the two clauses was simple. An interesting point is that the congruency effect on the reading time of the second clause is still observed when a gender cue on the pronoun agrees with only one antecedent (i.e., "Bill" is replaced by "Sue" in (4)). So, even when the pronoun itself is sufficient to determine its reference, the integration of the causal clause remains harder if it is not congruent with the bias of the main verb.

It could be argued that incongruent endings result in less plausible sentences. In their experiments, Stewart et al. used a pre-test to equate the plausibility of the congruent and incongruent versions. They reported a numerically smaller congruency effect (113 ms) when the pronoun had an ambiguous gender than when the pronoun was unambiguous (206 ms) (Stewart et al., 2000, Exp. 4; see also Garnham et al., 1992 for a similar trend). This persistence of the congruency effect in reading times for incongruent second clauses equated for inherent plausibility with congruent clauses whose subject pronouns unambiguously refer to one noun in a previous sentence suggests that part of the effect reflects the time to semantically integrate the predicate of the incongruent pronoun into a representation of the discourse structure that is constructed.

The other main source of on-line data regarding the implicit causality effect is the probe recognition paradigm. Here, the first or the second noun is presented as a target during the processing of a sentence such (4) or (5) containing an implicit causality verb. The subject has to decide, as quickly as possible, whether this word was present in the sentence. The position where the target is presented is usually varied in the causal clause: before the pronoun, after it, after the verb following the pronoun or at the end of the causal clause. The main goal is to determine if the implicit cause is more activated in working memory.

Some researchers have claimed that the implicit cause (the initiator in the terminology introduced by Osgood, 1970) is more activated than the other noun (the reactor) before the pronoun is perceived (McKoon, Greene, & Ratcliff, 1993; McDonald & MacWhinney, 1995; Greene and McKoon, 1995). This "Focusing theory" of the implicit causality does not rest on clear results. Testing before the pronoun, McDonald and MacWhinney (1995) found a faster recognition for the implicit cause, but all their experimental items had congruent endings, allowing strategic anticipation of the implicit cause. The occurrence of this strategic effect is consistent with probe recognition data reported by Garnham, Traxler, Oakhill and Gernsbacher (1996). They tested experimental items with congruent and incongruent endings, and they failed to show an early implicit causality effect (i.e., when the probes were presented after the pronoun). The experiments reported by McKoon and al. (1993) used the two types of endings, but the authors tested only one probe position: at the end of the causal clause. The authors used pronouns which were unambiguous in gender, as in (6) where the ending is not congruent.

(6) James infuriated Debbie because she had to write all the speeches.

In four experiments, they systematically found a recognition time advantage for the referent agreeing with the pronoun. An advantage in favor of the Initiator was only found in two experiments: in Experiment 2, this advantage was observed in probe recognition time, in Experiment 3, this advantage occurred in recognition errors for the probes. According to McKoon et al. (1993, p. 1046), the Initiator's advantage (sometimes observed) at the end of the sentence reflected "some effect of the initial greater

accessibility of the character in the initiator role [that] might survive to the end of the sentence". If this interpretation is correct, we should expect that the Initiator's advantage at the end of the sentence is related to the same (or a greater) advantage occurring before the end of the sentence. However, this prediction is inconsistent with the results reported by Greene et al. (1995) who tested the probes at earlier positions. For instance, using N1 biasing verbs, McKoon et al. (1993, Exp. 2) had showed a significant recognition time advantage for the Initiator (778 ms) relative to the Reactor (815 ms) at the end of the because-clause. In their Experiment 3, Greene et al. (1995) also used N1 biasing verbs in the main clauses, and they added sentences before the implicit verb sentence. Greene et al. (1995) measured the recognition times for the Initiator and the Reactor before N1 biasing verbs and immediately after the pronoun which followed these verbs. At these two points, they failed to show any advantage of accessibility for the Initiator. In particular, at the point where the "initial greater accessibility" of the Initiator should be observed (i.e. immediately after the pronoun which followed the N1 biasing verb and the connective "because"), the mean recognition times were 982 ms for the Initiator and 970 ms for the Reactor. Thus, ascribing the (non systematic) final accessibility advantage of the Initiator to a surviving prior advantage does not seem correct. For N2 biasing verbs, the experiments reported by Greene et al. (1995) showed data that were more consistent with the Focusing theory: immediately after the pronoun, the Initiator was more activated than the Reactor. However, this advantage could reflect a recency effect (cf. Stewart, Pickering, and Sanford, 2000, p. 424; and Garnham, 2001, p. 133; for more complete discussions).

This short review of probe studies shows first that probe recognition studies do not give unequivocal results concerning the on-line effects of the implicit causality of verbs. The studies that showed an implicit causality effect either tested only sentences with congruent endings, or showed unreliable effects in favor of the Initiator when the probes were presented immediately at the end of the because-sentence. Because the "Focusing theory" of the implicit causality predicts an earlier effect, emerging immediately after reading the connective "because," it has not been confirmed when it has been rigorously tested.

In their fourth experiment, Stewart et al. (2000) directly tested the Focusing theory by measuring the reading times of the two parts of sentences like (7) and (8), where "apologize" is a N1 biasing verb.

(7) Daniel apologized to Joanne because he / had been behaving selfishly.

(8) Joanne apologized to Arnold because he / didn't deserve the criticism.

The authors did not show a significant reading time difference on the first part of (7) and (8), even though the pronoun referred to the noun that was in the discourse focus only in (7). However, as mentioned earlier, the reading time of the second part was longer for (8), confirming that the incongruent ending was more difficult to process.

An alternative theory was proposed by Garnham et al. (1996) to explain the on-line effects of implicit causality on reading times. According to these authors, the congruency effect often noticed in these studies could reflect the difficulty in integrating a non-congruent cause with the first clause containing the verb. Stewart et al. (2000) suggested that implicit causality information influenced a later stage of processing "during, or after the process of assigning the explicit cause, and at the point when the interpretations of the two clauses are integrated into a single interpretation of the sentence as a whole." (p. 424).

Although the "Focusing theory" of implicit causality is not confirmed by several studies, it has a clear advantage relative to the "Integration theory": it allows a single explanation for results obtained in continuation studies and in reading time studies. Both in production and in comprehension, the processor should assign more activation to the Initiator of the implicit causality verb. In production, this would promote a reference to this Initiator in the continuation written by the subject. In comprehension, this would induce a shorter reading time to integrate a causal clause where this Initiator is mentioned (relative to a clause where the reactor is mentioned). On the other hand, the "Integration theory," as it is currently stated, can only explain the reading times results because it refers explicitly to the integration of an explicit cause with the first main clause.



In this paper, we would like to promote an elaboration of the "Integration theory" as an alternative view to the "Focusing theory", which can explain the clear off-line continuation effects observed in production. We suggest that at least part of the biases observed in continuation of fragments like (9) reflects the processing difficulty associated with finding a causal property consistent with the Reactor of the event (i.e. Arnold in (9)). This property is the predicate assigned to the entity referred after the "because" connective. In (8), this predicate is "didn't deserve the criticism". It is selected as a relevant property to involve the Reactor in a cause of the apologize. In other words, if a subject tries to imagine an ending of (9) with "he," this subject will need time to find a property consistent with the causal status of the Reactor. On the other hand, finding a property consistent with the Initiator (i.e. Joanne) would be easier. More precisely, if the subject starts with "she," finding an action or a property consistent will require less cognitive effort.

(9) Joanne apologized to Arnold because ...

We think that this view is intuitively plausible to all researchers who have tried to create "incongruent" endings for verbal materials in reading time experiments about implicit causality. These incongruent endings are hard to construct. However, an on-line measure that can detect this difficulty has not been employed. In this paper, we used an on-line writing production paradigm that enabled us to evaluate the time required to imagine an ending for the two possible versions of (10) :

(10) Joanne apologized to Arnold because (she / he) ...

The hypothesis was that the time to "imagine" a consistent property should be shorter if the pronoun refers to the Initiator. This hypothesis was tested in Experiment 1a and 1b where we measured the planning time when the subject read the pronoun. The paradigm used in Experiment 2 allowed us to measure the processing time of the anaphor before imagining the ending.

Because the Focusing theory claims that the implicit causality effects reflect the way the main clause is represented, they should occur immediately after reading the main clause and the causal connective. An immediate facilitation of the anaphoric process is predicted when the anaphor refers to the implicit cause. Stewart et al. (2000) formulated this prediction for the Focusing theory, "assuming pronouns are resolved immediately" (p.435). Although the immediacy of the resolution is under contest for pronouns, recent studies confirmed that the pronoun is immediately bonded to the most activated referent (Rigalleau and Caplan, 2000; Rigalleau, Caplan, and Baudiffier, 2004). The same immediacy has been checked for other types of anaphors (e.g., Almor, 1999 for superordinate noun anaphors). In Experiment 2, the "Focusing theory" predicted that the processing time of the anaphor should be longer if the anaphor refers to the reactor. Our prediction was different because we propose that implicit causality does not specifically enhance the activation level of the Initiator. So, we did not predict any difference in processing time on the anaphor itself. However, the implicit causality bias should facilitate the process of constructing a representation of a consistent causal property for the Initiator. Experiment 2 was similar to the Experiments 1a and 1b, but a noun phrase anaphor was used instead of a pronoun : the anaphor was a superordinate name of the antecedent (e.g., "musician" referring to "violinist"). This type of anaphor allowed us to add a new condition where the name in the because-clause did not refer to any name in the sentence. This "external name" condition was important because longer processing times were predicted for this "external name" than for noun anaphors referring to the Initiator or to the Reactor.

Our hypothesis, if it is confirmed, sheds some light on late effects noticed in continuation studies. Although these effects seem simply and directly explained by the Focusing theory, our hypothesis offers another explanation: subjects prefer to continue with the Initiator because it is easier to find a property consistent with the Initiator, not because this Initiator is more activated than the Reactor.

In summary, our study was designed to test an explanation of the usual continuation data that does not involve a pro-active effect of focalization. In the final Discussion section, we will consider the relation of this explanation to the "Integration Theory" and to the reading time studies that support this theory.

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### The on-line continuation method

In the following experiments, we wanted to get a measure of the time required to imagine a cause. In the implicit causality bias studies, continuation data are usually collected by asking subjects to write a continuation. This methodology allows long planning times, and we preferred to maintain this modality of production. In the two experiments here reported, the subjects pressed a pen on a graphic tablet when they were imagining the continuation. They were instructed to raise the pen as soon as they were sure of the continuation they wanted to write. This constraint was not difficult for subjects to fulfill.

### Experiments 1a and 1b

In Experiment 1, subjects read the first clause of a sentence. This first clause finished with a causal connective (i.e. "because"). The two first names in this first clause had different genders, and they were the subject and the object of a N1 biasing verb or of a N2 biasing verb. After this fragment, a pronoun agreeing with one of the two names was presented to the subject. At this point, the task was to imagine a consistent ending for the clause starting with this pronoun. When this ending was found by the subject, s/he wrote it on paper. This paradigm enabled us to measure the time a subject took to imagine a cause when this cause was consistent with either the first NP or the second NP of the first clause. Our expectation was that this time would be longer when the pronoun was not consistent with the bias of the verb.

In Experiment 1a, the subjects read the fragment at their own speed. In this way, we could get information about the reading times of the fragments. However, the subjects could pre-plan a potential continuation when they were reading the fragment (even if they did not know the pronoun at this point). In Experiment 1b, the fragment was presented word by word, using a rapid serial visual presentation. The presentation speed was quite rapid : 170 ms per word plus 17 ms per character. According to McKoon et al. (1993), this speed is consistent with a normal reading speed. In fact, Just and Carpenter (1987) considered a reading rate of 250 ms per word to be "normal" (p. 38).

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## Materials

Thirty-two verbs with an implicit causality bias were used to construct the stimuli. Sixteen verbs had a bias in favor of their grammatical subject (N1 biasing verbs), and sixteen verbs had a bias in favor of their grammatical object (N2 biasing verbs). The existence and the strength of the bias was checked in a pilot experiment involving 54 subjects (mean age: 23.45, SD = 3.36). They were students at the University Institute for Formation of Teachers (IUFM) of Angoulême. A first pool of 96 interpersonal verbs was used to construct the materials. The subjects were presented fragments containing two different-gender first names around a verb in the past tense, followed by the causal connective (e.g. "Jean a suivi Anne parce que ..." ["John followed Ann because ..."]). Half of the fragments began with a masculine first name, and different pairs of first names were used for each fragment. The order of the two names was reversed for half of the subjects, to control potential interactions between gender and implicit causality bias. The verbs used to construct the material were chosen on the basis of the material used in several English language experiments on implicit causality (in particular: Greene et al., 1995; Garnham, Traxler, Oakhill, & Gernsbacher, 1996; Rigalleau & Caplan, 2000); French translations of the verbs were used. Each fragment was presented on a sheet of paper, and subjects had to write a continuation for each fragment starting with a pronoun "he" or "she" referring to one of the two characters mentioned in the fragment. The 96 sentences were divided into two groups of 48 sentences, to make this continuation task shorter. Half of the subjects ( $N = 27$ ) had to continue 48 fragments, the other 27 subjects saw the other 48 fragments. Each subset of 48 fragments comprised 24 a priori N1 biasing verbs and 24 a priori N2 biasing verbs. The results allowed a selection of the final 32 verbs with same mean magnitude causality bias for both sets of 16 verbs (M = 81.5% of the subjects continued the fragment with a pronoun referring to the relevant noun).

The N1 biasing verbs were influencer (influence), troubler (trouble), mécontenter (displease), effrayer (frighten), charmer (charm), indigner (to make somebody indignant), irriter (irritate), énerver (annoy), désobéir (disobey), importuner (importune), supplier (implore), téléphoner (phone); persuader (persuade), convaincre (convince), mettre en colère (to make somebody angry) and s'excuser auprès de (apologize). The mean percent of N1 choice for these verbs was 81.5% (SD = 8.97). The N2 biasing

verbs were: juger (judge), mépriser (scorn), se méfier de (mistrust), redouter (dread), respecter (respect), apprécier (appreciate), craindre (fear), aimer (love), protéger (protect), engueuler (blame), secourir (assist), consoler (console), aider (help), punir (punish), embaucher (hire), and complimenter (congratulate). The mean percent of N2 choice for these verbs was 81.5% ( $\underline{SD} = 8.55$ ). Using the Frantex lexical frequency (New, Pallier, Ferrand, & Matos, 2001), the mean frequencies of the two types of verbs were compared (N1 biasing verbs:  $\underline{M} = 7.1$ ,  $\underline{SD} = 12.6$ ; N2 biasing verbs:  $\underline{M} = 7.4$ ,  $\underline{SD} = 12.4$ ). They were not significantly different: ( $F(1,30) < 1$ ). However, the mean number of letters (counting the auxiliary and the potential preposition required by some verbs) was slightly greater for the N1 biasing verbs ( $\underline{M} = 9.5$ ,  $\underline{SD} = 2.84$ ) than for N2 biasing verbs ( $\underline{M} = 7.9$ ,  $\underline{SD} = 2.14$ ) ( $F(1,30) = 3.1$ ,  $p = .08$ ).

For each of the verbs, two versions of a sentence were constructed. Sentences (11-12) illustrate the two versions. The slash indicates the break between the two segments that were successively presented to the subjects. Two first names with different genders, but with identical number of letters, were associated with one version; for this version the pronoun referred to the first NP. In the second version, a different pair of first names was used; although the number of letters in each first name was maintained, for this second version, the pronoun referred to the second NP. So one version had a pronoun congruent with the verb's bias, and the other version had an incongruent pronoun.

Version with a congruent pronoun

(11) Bernard a influencé Martine parce que / il

Masc. influenced Fem. because / he

Version with an incongruent pronoun

(12) Etienne a influencé Josiane parce que / elle

Masc. influenced Fem. because / she

Different pairs of first names were assigned to each verb. The mean number of letters of the first names was identical for the clauses containing N1 biasing verbs and for those containing N2 biasing

verbs ( $M = 7.25$  letters). All the first names used in this experiment were familiar and clearly marked in gender. Half of the N1 biasing verbs had a masculine first name as subject, and half had a feminine first name as subject (same for N2 biasing verbs). All the verbs were used in a past active form. This allowed the construction of a first list of 64 first clauses.

A second list was constructed by systematically reversing the order of the two first names in the clauses. Because the form of the pronoun was kept constant, this modification reversed the Congruency of the clause, as in (13-14). This inversion allowed us to control potential effects of gender on the strength of the implicit causality bias.

Version with incongruent pronoun

(13) Martine a influencé Bernard parce que / il

Fem. influenced Masc. because / he

Version with a congruent pronoun

(14) Josiane a influencé Etienne parce que / elle

Fem. influenced Masc. because / she

Twelve filler items were also constructed. These items were constituted with one verb and two same gender first names (6 items with two female first names, and 6 items with two male first names). The causal connective was replaced by "et" ("and") for these items. The pronoun was plural as illustrated in (15). Although the number of fillers was small, they permitted us to ensure that subjects could consider some contexts in which both names in the context could have similar roles in their continuation.

(15) Patrice a couru avec Anthony et / ils

Peter ran with Anthony and / they

Each of the two lists of 64 experimental items was mixed with the same 12 filler items.

For each list, five pseudo-randomized orders were established avoiding the same verb occurring in two successive items.

Four training items were also constructed: three had the experimental connective (i.e., "because"), and one had the filler connective (i.e., "and").

### Procedure

Subjects were tested individually in a quiet room. Successive stimuli were presented in black characters (Times New Roman 20-point bold characters) in the center of a PC computer screen with a white background. The subjects used a graphic digitalizing tablet Wacom SC-421E to trigger the appearance of stimuli, and to write the continuation. Figure 1 illustrates the different zones of this tablet.

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Figure 1 here

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The procedure in the Experiment 1a was the following. To start a trial, the subject put the point of the pen on a departure (black) square which was outside the active zone of the tablet. A fixation point appeared on the screen, at the position where the first word of the following fragment should appear. The experimenter pressed a button which activated two events: the appearance of the fragment (e.g. "John annoyed Ann because") on the screen, and the onset of a measurement of what will be called the "reading time" of this fragment. Once the subject had read this fragment, s/he moved the lead of the pen onto a second (white) square on the right (distance from the departure square = 15 mm). This second square was on the part of the graphic digitalizing tablet where presses of the pen were recorded. When the lead pressed this second square, four events occurred: the fragment disappeared on the screen, it was replaced by a pronoun, presented in capital letters (e.g. "HE"), the internal clock of the computer finished the measurement of the reading time and started the measurement of what will be called the "planning time" of the continuation. The subject had to imagine a continuation. S/he was instructed to raise the pen from the square when s/he was sure of the continuation s/he wanted to write. Raising the pen activated two

events: the pronoun disappeared from the screen, and the internal clock finished the measurement of the "planning time." Finally, the subject wrote the continuation on a graphic digitalizing tablet, where all the movements and pauses of the pen were recorded. To finish the trial, the subject pressed an "End" square at the bottom of the tablet. After this, the pen was placed on the departure square of the next line to start the next trial. As can be seen on Figure 1, there were six trials per sheet of paper. The experimenter changed the sheet when the subject finished the six trials.

The instructions required the subject to put the pen on the departure square and to look at the fixation point. When the fragment appeared, the subject read it silently. When s/he had finished reading, s/he moved the pen to press the second square which triggered the appearance of the pronoun. Then the subject had to imagine a consistent continuation for the fragment plus the pronoun. When this continuation was found, the subject could raise the pen from the second square and write the continuation on a line at the right of the square.

In Experiment 1b, the subject started a trial by pressing the second square. This triggered the appearance of the fragment. This fragment appeared segment by segment until the segment containing the pronoun. Each fragment was presented with the following segments : Noun 1/ verb/ [preposition] Noun 2/ parce que / pronoun /. Each segment appeared in the center of the screen. The duration of presentation of each segment was calculated with the following formula : 170 ms per word + 17 ms per character. When the pronoun disappeared, the subject had to imagine a consistent continuation. The subject raised the pen from the second square only when the continuation was found. The planning time measure started at the offset of the pronoun.

Reading times and planning times (as well as writing times) were collected using software G-Studio (Chesnet, Guillabert, & Esperet, 1994).

### Subjects and Design

The subjects were students of the University of Poitiers. Twenty subjects participated in Experiment 1a (16 females, 4 males, mean age: 23; SD = 5.4). Twenty different subjects participated in Experiment 1b, (16 females, 4 males, mean age: 22; SD = 3.8). As mentioned in the material section, for



each experiment, there were two lists. Ten subjects were assigned to the first type, and 10 other subjects to the second type.

There were two variables in the design: the causality bias of the verb in the main clause (N1 biasing verb vs. N2 biasing verb); and the congruency of the pronoun relative to this bias (congruent vs. incongruent). Each subject saw each verb with a congruent pronoun and with an incongruent pronoun.

## Results

For Experiment 1a, the 1,280 continuations written by the subjects were examined by two independent raters to see whether they were consistent with the main clause. Three scores could be assigned to a continuation: 1 = only consistent with the pronoun; 2 = possible (i.e. could be consistent with the pronoun "he" or "she"); 3 = not consistent with the pronoun. The initial independent ratings disagreed on only 36 (2.8%) of the continuations. All initial disagreements were resolved by discussion. Forty continuations received score 3, so 96.8% of the continuations were consistent with the main clause (63 (4.9 %) were assigned score 2), indicating that subjects followed the instruction.

Two response times were analyzed: the reading time of the first fragment, and the planning time. Hypotheses were articulated about the planing time. For these two dependent variables, the same data trimming was carried out. For each subject, the mean time and the standard deviation was computed for each of the four conditions. The times that were greater than 2.5 standard deviations from the mean were defined as outliers. They were replaced by the maximum time of the subject in the relevant condition after extraction of the outliers. This method was used because we did not want to replace a long time by the mean, a method which can falsely increase the chances of making "type I error". For all the experiments reported in this paper, the replacement affected less than 5% of the data.

These data were analyzed in two analyses of variance (ANOVAs) for each dependant variable. The first ANOVA used subjects as a random factor ( $F_1$ ) and involved two within-subject factors: Verbal bias (N1 biasing verb vs. N2 biasing verb); Congruency of the final pronoun with the verb bias (congruent vs. incongruent). The second ANOVA used items as a random factor ( $F_2$ ): it involved the same factors, but Congruency was a within-items factor, and Verb bias was a between-items factor.

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Table 1 here

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Table 1 reports the mean reading times in Experiment 1a. For the reading times, the only effect which was significant was the main effect of the verb bias ( $F_1(1,19) = 24.54, p < .01$ ;  $F_2(1,30) = 9.1, p < .01$ ). The mean reading time was longer for fragments containing a N1 biasing verbs. The effect of congruency was not significant ( $F_1(1,19) = 1.37$ ;  $F_2(1,30) = 0.52$ ); the two way interaction was also not significant ( $F_1(1,19) = 0.03$ ;  $F_2(1,30) = 0.23$ ).

Table 2 reports what we call the mean planing times (i.e., time between the appearance of the pronoun on the screen and the raising of the pen to write the continuation).

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Table 2 here

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The ANOVAs revealed that the two main effects were significant. Consistent with the hypothesis, the planing time was longer when the subject had to imagine an ending following an incongruent pronoun ( $F_1(1,19) = 21.81, p < .01$ ;  $F_2(1,30) = 26.69, p < .01$ ). The main effect of the verb bias was also significant ( $F_1(1,19) = 9.5, p < .01$ ;  $F_2(1,30) = 7.73, p < .01$ ). As for the previous reading time, a longer time was observed for N1 biasing verbs than for N2 biasing verbs. The two-way interaction was only significant by items ( $F_1(1,19) = 2.47, p > .1$ ;  $F_2(1,30) = 4.38, p < .05$ ). For our purpose, it should be noticed that the congruency effect was significant for the two types of verbs (for N1 biasing verbs:  $F_1(1,19) = 11.77, p < .01$ ;  $F_2(1,15) = 18.12, p < .01$ ; for N2 biasing verbs:  $F_1(1,19) = 6.25, p < .05$ ;  $F_2(1,15) = 8.65, p < .01$ ).

In Experiment 1b, on six occasions subjects did not produce completions, in each case indicating they had not retained the lead-in fragment when the pronoun appeared. The 1,274 continuations written

by the subjects were examined by the same two independent raters to see whether they were consistent with the main clause. The initial independent ratings differed only on 19 (1.5%) of the continuations. These disagreements were all resolved by a discussion between the two raters. Only 50 continuations received score 3, so 96.1% of the written continuations were consistent with the main clause (only 58 (4.6 %) were assigned score 2), indicating that subjects followed the instructions.

For Experiment 1b, the mean planning times are reported in Table 2. The ANOVAs on planning times also showed a main effect of congruency ( $F_1(1,19) = 26$ ,  $p < .01$ ;  $F_2(1,30) = 37.1$ ,  $p < .01$ ) with a longer time to imagine an ending following a pronoun referring to the Reactor. There was a main effect of verb bias ( $F_1(1,19) = 8.8$ ,  $p < .01$ ;  $F_2(1,30) = 5.7$ ,  $p < .05$ ); again, subjects took more time to imagine an ending following a N1 biasing verb. The two-way interaction was not significant ( $F_1(1,19) = 0.9$ ;  $F_2(1,30) = 1.4$ ,  $p > .05$ ). The congruency effect was significant for the two types of verbs (for N1 biasing verbs:  $F_1(1,19) = 16.9$ ,  $p < .01$ ;  $F_2(1,15) = 18.01$ ,  $p < .01$ ; for N2 biasing verbs:  $F_1(1,19) = 8.7$ ,  $p < .01$ ;  $F_2(1,15) = 22.7$ ,  $p < .01$ ). Thus the RSVP version of the experiment gave results which were similar to the version where the subjects could process the introductory fragment at their own pace.

Our hypotheses concerned what we call the "planning time;" i.e., the delay before the subject raised the pen to write the continuation. However, it could be argued that some subjects raised the pen before having finished thinking of the continuation, even if the instruction explicitly instructed them not to do so. Because G-Studio records all the movements and pauses of the pen during the writing activity, we also analyzed the next time recorded on the tablet. This time corresponded to the time between a subject's raising the pen from the second square and the following press of the pen on the tablet to write the first word in the continuation. If the subjects followed the instructions, this time should be short relative to the planning time, and it should not be affected by the variables manipulated in the experiment. For the experiments reported in this paper, we did not find reliable effects of the factors at the .05 level by subjects or by items. The mean value of this time was 1,073 ms ( $SD = 422.6$ ) in Experiment 1a, 1,038 ms ( $SD = 289.7$ ) in Experiment 1b, (and 979 ms ( $SD = 339.6$ ) in Experiment 2). These values were clearly less than the mean planning time values (Exp. 1a: 6,679 ms; Exp. 1b : 4,765 ms ; Exp. 2: 13,000 ms). The other times recorded by the graphic tablet were not analyzed because they

varied according to the specific words written by each subject for each continuation. Although we cannot reject the possibility that some planning occurred during the writing, the small values for the time following the "planning time, " and the results for the "planning time" suggest that subjects did follow the instructions and did not raise the pen before having finished at least part of the planning process.

## Discussion

In these two experiments, there was a clear congruency effect on the planning time. Subjects took more time to imagine a cause consistent with a pronoun that did not fit the causality bias of the previous verb.

The main effect of verb bias on the two response times suggests that subjects had more difficulty processing a verb when its causal bias was in favor of N1. A similar effect was reported by Garnham, Oakhill and Cruttenden (1992, Exp 4); however Stewart et al. (2000, Exp 2-4) did not report this effect. This effect seems related to unknown lexical properties of the specific verbs used in different experimental materials. The frequency of the two types of verbs is a poor candidate to explain the effect because the two types of verbs did not differ for this dimension ( $F(1, 30) < 1$ ). However, we noted in the Materials section that N1 biasing verbs were slightly longer than N2 biasing verbs in our material. We computed mean reading speed by dividing the reading times by the number of characters in the read fragment. For Experiment 1a, the ANOVAs with this cue as dependent variable still showed a significant effect of verb (for N1 biasing verbs:  $\underline{M} = 203$  ms/char.;  $\underline{SD} = 63$ ; for N2 biasing verbs:  $\underline{M} = 190$  ms/char.;  $\underline{SD} = 58$ ), although this effect was only significant by subjects ( $F_1(1,19) = 8.9, p < .01$ ;  $F_2(1,30) = 1.91, p > .05$ ). The raw times are reported in Table 1. It seems that at least part of the effect of verbs reflected differences in number of characters between the two types of verbs.

The reading times in Experiment 1a were quite long relative to "usual" reading times in such experiments (e.g. between 2 and 3 seconds in Stewart et al., 2000). This aspect of the results could suggest two interpretations. First, subjects might have tried to plan the continuation when they were reading the first fragment. This was difficult because at the time the first clause was read, subjects did not know which participant would be referred to by the pronoun. However, they could try to plan a

continuation that was more likely. In this case, they would plausibly plan a continuation that contained a congruent pronoun. The longer "planning times" in the incongruent condition would reflect the fact that subjects had to abandon their first attempt to imagine a cause. This interpretation will be considered in Experiment 2 where the processing time of the anaphora will be measured, it should be faster when the anaphora refers to the Initiator. However, the results of the Experiment 1b suggest that this interpretation is not sufficient to explain the congruency effect on planning times. The RSVP rate was quite fast for subjects, on six occasions, subjects were not able to complete the fragments because the presentation was too fast to allow the retention of the fragment. This difficulty was never encountered by the subjects in Experiment 1a. It suggests that the fast RSVP rendered the reading task more difficult limiting the possibility of a preparation while reading the lead-in fragment. Although we cannot assert that the fast RSVP precluded any strategic planning. A second factor that could explain the long reading times is that subjects tried to covertly rehearse the fragment because the appearance of the pronoun triggered the disappearance of the fragment. This covert rehearsal process would be expected to be identical in all the conditions. Whatever the appropriate explanation of the long reading times in Experiment 1a, the results of the Experiment 1b showed that they were not a crucial factor in explaining the planning times results.

### Experiment 2

Experiments 1a and 1b showed longer planning times when subjects had to produce a continuation for a pronoun which was not consistent with the causal bias of the verb. However, the onset of this "planning time" was the instant when the pronoun appeared on the screen. The planning time effect could be consistent with the Focusing theory of the implicit causality effect (McKoon et al., 1993). According to this theory, readers focus their attention on the implicit cause of the verb. The process of focusing attention can be viewed as an anticipation preparing the reader to process an anaphor referring to the implicit cause. At least part of the longer planning time for continuations of incongruent pronouns could reflect the fact that these pronouns did not match this anticipation, or that subjects first tried to match the pronominal gender with the most active NP (the implicit cause). In the Experiment 2, we

directly examined this hypothesis by changing two main aspects of the experiment: the first concerned the procedure, the second concerned the materials.

First, an immediate naming latency of the anaphor was measured to see if the anticipatory effect suggested by the Focusing theory would immediately accelerate the time required to process an anaphor referring to the Initiator of the previous clause. Marslen-Wilson, Tyler, & Koster (1993) used a cross-modality naming task where subjects had to listen a linguistic context and to name a visual probe corresponding to an anaphor which terminated this context. They reported faster naming latencies when the context made the anaphoric referents highly accessible. Furthermore, their study showed that naming latency could be sensitive to discourse focus.

In the current experiment, our main expectation was that the Initiator and the Reactor should not elicit different naming latencies for their respective anaphors (contrary to the naming latency advantage for the Initiator predicted by the Focusing Theory). However, a null effect can also reflect the insensitivity of the task. We decided to include a new condition where we expected to get longer naming latencies, even if the same words were to be named. In this condition, the anaphoric pronouns were replaced by superordinate semantic anaphors, as in (16) where the anaphor refers to the Initiator, and in (17) where it refers to the Reactor. Almor (1999) showed that subordinate noun phrase anaphors (like pronouns) preferentially refer to focused antecedents, and thus the Focusing theory makes the same prediction for NP anaphors as for pronouns (Stewart et al. (2000) reported similar congruency effects when pronouns were replaced by repeated name anaphors). In our experiment, the replacement of pronouns by full noun phrases allowed us to include a condition where the final word of a context would not be anaphoric, as in (18). This new condition will be called the "External Name" condition. Thus, the same target words appeared in contexts where they did not refer to any previous word, or in conditions where they referred either to the Initiator or to the Reactor. This control allowed to check whether the naming latency was sensitive to the semantic relation existing between the target word and each of the referents in the context.

- (16) Le violoniste a troublé le matelot. C'est parce que le musicien ...

The violinist troubled the sailor. This is because the musician ...

- (17) Le violoniste a troublé le matelot. C'est parce que le marin

The violinist troubled the sailor. This is because the seaman ...

- (18) Le violoniste a troublé le matelot. C'est parce que le fauve ...

The violinist troubled the sailor. This is because the wildcat ...

In the psycholinguistic literature on superordinate semantic anaphora, these anaphors are usually presented in a sentence following the sentence that contains the antecedent (e.g. Garrod and Sanford, 1977; Dell, McKoon, and Ratcliff, 1983; Garnham, 1989; Greene et al., 1992; Almor, 1999). Accordingly, as illustrated in (16-18), we placed the causal proposition in a different sentence from that containing the target word (which is underlined). The anaphoric name could refer either to the Initiator (e.g., musician) or to the Reactor (e.g., seaman).

Again the Focusing theory predicts a longer naming latency for the Initiator. However Integration theory does not predict any difference between the two anaphors. In the "External Name" condition, both the Focusing theory and the Integration theory predict a longer naming latency than in the anaphor conditions because the subject could not take the name as referring to a previously mentioned entity. Concerning the planning times, we predicted a longer time in the condition where the anaphor referred to the Reactor than to the Initiator. The condition with an external name starting the continuation should induce longer planning time than the continuation with a name referring to the Initiator or to the Reactor because the absence of any coreference between two sentences makes the integration more difficult.

## Materials

The materials used in the previous experiments were changed by replacing the names by social functions or animals. This replacement required three main steps. First, two verbs (one N1 biasing verb: "influence"; and one N2 biasing verb: "judge") were removed from the materials because we needed to construct three blocks of fragments with the same number of sentences. The two verbs were those which

had the smallest causal bias in the initial paper and pencil evaluation. Second, each of the thirty remaining verbs was associated with a different pair of names. The two names had same gender to avoid potential strategies based on gender processing which could avoid a complete semantic processing of the words. For each of the two names, a superordinate name was selected: this name could only refer to one of the two names in the pair. The two superordinate names did not differ in mean frequency or in mean length. Because the occurrence of social function names could modify the causal bias of the verb, and because we used a new construction involving two sentences, we undertook a new paper and pencil evaluation of the causal bias. This third step involved 40 subjects. For each verb, two versions were presented to 20 subjects. The order of the two names was reversed in the two versions (e.g. "Le violoniste a troublé le matelot. C'est parce que ... vs "Le matelot a troublé le violoniste. C'est parce que ..." ["The violinist troubled the sailor. This is because ..." vs. "The sailor troubled the violinist. This is because ..."]). Two judges evaluated the continuations to define which of the two names was used in subject position. The results showed that the causal bias was reversed between the two versions for 3 N1 biasing verbs and for 3 N2 biasing verbs. For N1 biasing verbs, these verbs were "effrayer" (frighten), "importuner" (importune), and "supplier" (implore). For N2 biasing verbs, the three verbs were "redouter" (dread), "secourir" (assist), and "aider" (help). These items were removed from the materials, leaving twenty four verbs (12 N1 biasing verbs and 12 N2 biasing verbs). Collapsing across the two versions of the fragments, for N1 biasing verbs, the mean percentage of N1 continuations was 73.5% (Min = 62.5% ; Max = 85%) and for N2 biasing verbs, the mean percentage of N2 continuations was 81.8% (Min = 67.5% ; Max = 92.5%). Because the final number of verbs of both type was small, we preferred to eliminate the type of verb factor from the final design, although each subject saw four N1 biasing verbs and four N2 biasing verbs in each condition. Globally, the causal bias for all the verbs was 77.7% of continuations in favor of the Initiator. Using the Frantex lexical frequency proposed by New et al. (2001), the mean frequencies of the anaphoric names used for each verb were compared (anaphor for N1 :  $\underline{M}$  = 16.5,  $\underline{SD}$  = 24.6; anaphor for N2 :  $\underline{M}$  = 20.1,  $\underline{SD}$  = 28.5). These were not significantly different ( $F(1,23) < 1$ ). The two anaphoric names did not differ in number of letters (anaphor for N1 :  $\underline{M}$  = 8.33,  $\underline{SD}$  = 2.1; anaphor for N2 :  $\underline{M}$  = 8.29,  $\underline{SD}$  = 1.45), ( $F(1,23) < 1$ ).



In the final materials, each of the 24 verbs was inserted in 6 versions, illustrated for one verb in examples (19)-(21). In the two first versions, the final name referred to the Initiator; in the two following versions, the final name referred to the Reactor, in the two final versions; the final name referred to an external character. For each condition, the order of the two names in the fragment was reversed.

Anaphor referring to the Initiator (congruent):

(19a) Le violoniste a troublé le matelot. C'est parce que le musicien ...

The violinist troubled the sailor. This is because the musician ...

(19b) Le matelot a troublé le violoniste. C'est parce que le marin ...

The sailor troubled the violinist. This is because the seaman ...

Anaphor referring to the Reactor (incongruent):

(20a) Le violoniste a troublé le matelot. C'est parce que le marin ...

The violinist troubled the sailor. This is because the seaman ...

(20b) Le matelot a troublé le violoniste. C'est parce que le musicien ...

The sailor troubled the violinist. This is because the musician ...

Non anaphor referring to an external name:

(21a) Le violoniste a troublé le matelot. C'est parce que le fauve ...

The violinist troubled the sailor. This is because the wildcat ...

(21b) Le matelot a troublé le violoniste. C'est parce que le dresseur ...

The sailor troubled the violinist. This is because the tamer ...

The final names used in the "External Name" condition were used as anaphors in the anaphoric versions of other experimental fragments. This control allowed us to get naming latencies for the same names in the three conditions of the experiment (i.e., "musician" could be presented either as referring to the Initiator, or as referring to the Reactor, or as referring to an external character in the sentence "Le dompteur a craint le lion. C'est parce que le musicien ..." ["The trainer feared the lion. This is because the musician ..."]).

There were 9 filler fragments with the connective "but." Three fragments finished with an anaphoric name referring to the first name, three fragments had an anaphoric name referring to the second name, and three fragments finished with a name referring to an external character. There were six practice items, two involving a third name referring to an external character.

### Procedure

As in Experiment 1b, each subject started a trial by pressing the second square. This press triggered the presentation of the successive words in the fragment. The presentation speed of the fragment was similar to Experiment 1b. The segmentation used for the initial fragment was also identical, but the names in the first fragment were presented together with their determiners. The target name serving for the naming latency measure was presented after its determiner to get a better measure of the naming latency of this name. Thus the segmentation was : / The N1 / verb / [preposition] the N2 / parce que / the / name /). The final name was presented with non capital red letters (the preceding words were in black letters). When the target word appeared, the internal clock started the measurement of the "naming latency" for the name. The subject had to name the red word as quickly as possible in a microphone. When the microphone was triggered, the target word disappeared and the internal clock of the computer started the measurement of what will be called the "planning time" of the continuation. The subject had to imagine a continuation, and was instructed to raise the pen from the second square when s/he was sure of the continuation s/he wanted to write. The raising of the pen from the second square finished the measurement of the "planning time." Finally, the subject wrote the continuation on a graphic digitalizing tablet where all the movements and pauses of the pen were recorded.

### Design and subjects

There was one factor in this experiment : the name following "because" was either an anaphor referring to the Initiator (starting a congruent ending), or an anaphor referring to the Reactor (starting an incongruent ending), or a name referring to an external character. This factor was within subject and within item.

The 24 fragments were divided in three blocks of 8 fragments. Each block contained four N1 biasing verbs and four N2 biasing verbs. Three first lists containing the 24 fragments were constructed. In each list, the fragments in each block occurred in one of the three conditions. Three other lists were constructed where the order of the two names in the fragment was reversed. So each of the 6 versions of a specific fragment (cf. 19-21) was assigned to a different list. The order of the fragments in each list was pseudo-randomized.

Twenty four subjects participated in this experiment (19 women, 5 men, mean age: 23.7 years old,  $SD = 5.5$ ). They were students of the University of Poitiers. Two subjects were replaced because they reported difficulties reading the fragments with the rapid presentation speed used in this experiment: for many fragments they were unable to imagine any continuation. Six groups of four subjects read each of the six lists. With this design, a subject read a specific verb only once, and s/he named a specific target name only once.

## Results

The 576 continuations written by the subjects were examined for content by the same two independent raters who evaluated the continuations in Experiments 1a and 1b.

For the 384 anaphoric continuations, the same criteria as in Experiments 1a and 1b were used to evaluate consistency. Three scores could be assigned to a continuation: 1 = only consistent with the anaphoric referent; 2 = possible (i.e. could be consistent with both referents); 3 = not consistent with the anaphor. The initial independent ratings disagreed on only 16 (4.2%) of the continuations. All initial disagreements were resolved by discussion. Globally, only 40 anaphoric continuations received score 3, so approximately 90% of the continuations were consistent with the main clause (among them only 22 (6.4 %) were assigned score 2), indicating that subjects followed the instructions.

For the 192 non-anaphoric continuations, the rating criteria had to be changed. The score 1 was assigned if the continuation was a consistent cause, the score 2 was assigned if the continuation could not be thought as a consistent cause. The two raters disagreed on only 13 (6.8%) of the continuations. All initial disagreements were resolved by discussion. Seventy continuations (36.4%) received score 2. This suggests that subjects had great difficulty imagining a consistent cause involving an external character.

Because each subject read only four N1 verbs in each of the three conditions, we eliminated the type of verb factor from the analysis. This decision allowed us to obtain eight data points in each condition for each subject. For the naming latencies, 2.36 % of the data were replaced by the mean of the subject in the relevant condition. These were missing data due to repetitions in the microphone. Here, replacing such data by the maximum naming latency seemed to be incorrect because the long value obtained was only due to a technical problem: the subject took a "normal" time to name the word even if the microphone did not detect this naming answer (see Marslen-Wilson et al., 1993). This was not the case for the base planning times where very long times could not be ascribed to technical problems. For these times, as in Experiments 1a and 1b, we replaced an extremely long time by the maximum time of the subject after rejection of the outlier. The planning time outliers were defined as the values more 2 standard deviations around the mean of the subject in the condition. Four per cent of the planning time data were replaced. Using a cut-off at more 2.5 standard deviations, as in the first experiment, did not result in any replacement because the number of data by subject and by condition (8 data) was reduced relative to Experiments 1a and 1b. However, ANOVAs conducted on the data with and without replacement gave the same significant and non significant results. We report the data with replacement to allow a comparison of the mean planning times obtained in Experiment 2 and in the two previous experiments. Use of no replacement values would have resulted in longer mean planning times due to the absence of outliers.

The mean naming latencies and the mean planning times for the three conditions are reported in Table 3.

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Table 3 here

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For the naming latencies, the ANOVAs revealed a main effect of the condition ( $F_1(2,46) = 11.6$ ,  $p < .01$ ;  $F_2(2,46) = 6.3$ ,  $p < .05$ ). We computed two orthogonal tests of contrasts (Keppel and Wickens, 2004). The first contrast showed no significant difference between the mean naming latencies in the

Congruent condition and in the Incongruent condition (both  $F_s < 1$ ). The second contrast opposed the mean naming latencies in the two anaphoric conditions and the mean naming latency in the "external name" condition ( $F_1 (1,23) = 16.4, p < .01$ ;  $F_2 (1,23) = 9.8, p < .01$ ): naming latencies were longer when the word referred to an external character.

For the planning times, there was again a main effect of the condition ( $F_1 (2,46) = 7.4, p < .01$ ;  $F_2 (2,46) = 12.8, p < .01$ ). The same orthogonal contrasts used for naming latencies were computed for planning times. These contrasts revealed that the mean planning time was longer in the Incongruent condition than in the Congruent condition ( $F_1 (1,23) = 17.1, p < .01$ ;  $F_2 (1,23) = 16.1, p < .01$ ). The mean planning time was also longer in the External condition than in the Anaphoric conditions ( $F_1 (1,23) = 4.9, p < .05$ ;  $F_2 (1,23) = 10.9, p < .01$ ).

## Discussion

Experiment 2 confirmed the results of Experiments 1a and 1b. Again, subjects took more time to produce an ending consistent with the Reactor. An important result concerned the naming latencies, which were sensitive to the non-anaphoric status of the external name. This result confirmed that the naming latency was a measure sensitive to the anaphoric status of a noun, even if this measure did not show any difference between an anaphor referring to the Reactor and an anaphor referring to the Initiator.

It should be noticed that the mean planning times obtained in Experiment 2 were much longer than those obtained in the previous experiments. This could reflect the fact that subjects had to consider the properties associated with specific social functions when they were planning their continuations. In the previous experiments such specific properties were not associated with the first names used in the fragments. This result suggests that the time required to find a predicate depends on the effort required to make the continuation consistent with the constraints imposed by the previous fragment: many continuations can be consistent with a male character named Franck, fewer predicates will be consistent with a violinist. The selection of an appropriate predicate requires more time when this predicate must satisfy more constraints. The size of the congruency effect was also greater (approximately 3 sec) in the

current experiment than in the previous experiments, suggesting that subjects made a greater use of these specific properties when they found it difficult to find a cause.

Finally, we note that the external name condition was very difficult. This difficulty resulted in longer naming latencies, in longer planning times, and in less consistent continuations. The external name condition was not inappropriate as revealed by the 63.6% of the continuations that were consistent. Two examples of consistent continuations written by subjects are given in (22)-(23)

(22) The trainer feared the lion. It is because the musician frightened the animal.

(23) The ambassador phoned the repairman. It is because the thief stole the keys of his car.

The establishment of a new referent and the computation of a potential causality relation involving this referent required considerable effort on the part of the subjects. As illustrated by the examples, the subjects imagined an additional relation between the new referent and one of the two characters in the fragment.

The results of Experiments 2 confirm that the difficulty in imagining an explicit cause depends on the character who is involved in this cause. If the anaphor referred to the Initiator of the previous clause, people took less time to imagine a cause than if the pronoun referred to the Reactor. However, the implicit causality bias did not seem to affect the level of activation of the Initiator "proactively", as the Focusing theory maintains. Our results point to a delayed effect of implicit causality: finding a causal predicate for an anaphor referring to a Reactor is a more difficult process than finding a predicate for an anaphor referring to an Initiator.

### General Discussion

The three experiments reported in this paper showed that the time required to find an explicit cause for an event depends on the implicit causality bias of the verb involved in this event, on the lexical status of the characters involved in the event, and on the character involved

in the explicit cause. In Experiments 1a and 1b, imagining a causal property consistent with the Reactor required 1.4 seconds more than imagining a causal property consistent with the Initiator. This delay was even longer in Experiment 2. In Experiment 2, replacing first names by social functions or animals increased the time required to find a consistent ending. We suggested that this longer time reflected the fact that consistent endings had to satisfy more semantic constraints when the nouns mentioned in the fragment referred to social functions.

The Focusing theory of the implicit causality bias predicted a longer processing time when an anaphor referred to the Reactor than when it referred to the Initiator . This prediction was not confirmed in the Experiment 2, although the naming latency of anaphoric nouns was faster than the naming latency of external nouns. If we take into account the numerous studies that have not found results consistent with the Focusing theory (Rigalleau and Caplan, 2000, 2004; Garnham et al., 1996; Stewart et al., 2000), we must conclude that the Focusing theory offers an unsatisfactory way of explaining the on-line effects of implicit causality.

The Initiator and Reactor can have the same level of activation just after the causal connective, but it is more difficult to find a property consistent with the causal status of the Reactor. This can explain why the continuation data generally obtained with implicit causality verbs show a preference for continuations referring to the Initiator.

This view of the implicit causality effects observed in production is consistent with one aspect of the results reported in reading times studies (e.g. Garnham et al., 1992; Stewart et al., 2000; Rigalleau, Caplan, & Baudiffier, 2004). As mentioned in the Introduction, there are cases in which equal congruency effects on reading times of the second clause of sentences with morphonologically unambiguous and morphonologically ambiguous pronouns ((24)/(25) and (26)/(27)), respectively have been reported, e.g., Stewart et al., 2000).

(24) Thomas confessed to Daphne because he / had stolen the money.

(25) Daphne confessed to Johnny because he / would not be judgmental.

(26) Thomas confessed to Johnny because he / had stolen the money.

(27) Thomas confessed to Johnny because he / would not be judgmental.

This is consistent with the view that there is no preparation for a pronoun that is congruent with the verb bias. The congruency effect is due to the predicate following the pronoun and not to the relation of the pronoun with the main clause per se. According to the Integration Theory, the congruency effect reflects the longer time needed to integrate the main clause and the causal clause when the predicate of the causal clause is consistent with the Reactor of the previous event. Our results suggest that this type of predicate is also more difficult to imagine. Thus both our production experiments and reading times studies converge in locating the main difficulty associated with incongruent endings at a point when the subject is integrating the predicate following the anaphor. We would like to finish this general discussion by considering an hypothesis concerning one aspect of this process.

We suggest that the processing difficulty associated with an incongruent predicate is due to the amount of relevant information constraining the integration of this type of predicate. This could be greater for incongruent predicates (i.e. predicates following the Reactor) than for congruent predicates. We suggest that this factor also influences the time required to imagine the predicate in our production experiments. The idea is consistent with the results of the Experiment 2, which showed that planning was more difficult when the continuation had to satisfy more constraining contexts where the names referred to social functions or animals.

The connective "because" requires that the predicate make explicit a potential cause of the previous event. This constraint is present both for congruent and incongruent endings. Using the linguistic analysis proposed by Levin (1993), McKoon et al. (1993) argued that implicit causality verbs denote events where one participant is the Initiator, and the other is the Reactor. The Initiator corresponds to the implicit cause of the event. This means that when a congruent ending is present to integrate, the reader has to check that the predicate in this ending is consistent with the Initiator as a cause of the previous event. We suggest that, in many cases if not in all cases, the Reactor does not have to be considered to check that the congruent clause is consistent.



Two congruent instances will serve to illustrate this point. First in (24), where the ending is congruent, the ending seems equally consistent if Thomas stole the money from Daphne or if he stole the money from somebody else. The fact that the Reactor (i.e. Daphne) is involved in the final predicate is not important. Second, in (28), where the verb "to blame" is a N2 biasing verb, and "Bill" in the second clause refers to the Initiator of the "blaming" reaction, the pronoun in the predicate can refer either to John or to someone else.

(28) John blamed Bill because Bill hated him.

In (24), as in (28), the action ("stealing money" or "hating someone") is a behavior consistent with the Initiator as a cause. Considering the properties of the Reactor is not needed to check that the predicate in the because-clause is consistent with the first clause.

In contrast, in sentence (25), where the ending is incongruent, it seems that the predicate "would not be judgmental" satisfies a constraint that the verb "confess" imposes on its Initiator "Daphne". The verb "confess" implies that the Initiator behaved improperly. This property of the Initiator is essential to understanding why "being not judgmental" is a property consistent with the Reactor (i.e. Johnny) of the confession. The same phenomenon is easily visible in (29), where the subject anaphor refers to the Reactor of the blame, and the ending is incongruent. Only (29a) is a coherent interpretation of (29) because it also refers to the Initiator. In (29a), the verb "blame" implies that the Initiator "Bill" acted in some way injurious to the Reactor "John". This implication constitutes a constraint which is perfectly satisfied by the ending of (29a), and not by the ending of (29b). To make (29b) coherent, one has to imagine a reason that John hating Max would lead to John blaming Bill; one way or another, the second clause involves the Initiator.

(29) John blamed Bill because John hated him.

(29a) John blamed Bill because John hated Bill.

(29b) ?? John blamed Bill because John hated Max.

These two examples suggest that checking the consistency of an incongruent ending often requires considering the Initiator or properties of the Initiator. This remark is consistent with the analysis of incongruent endings proposed by McKoon et al. (1993). In incongruent endings, the predicate in the because-clause "explains what property or action of the reactor made the initiator's property effective or the initiator's action possible" (McKoon et al., p.1042). This suggests that both the Initiator and the Reactor exert constraints on the integration of incongruent endings. On the other hand, congruent endings can often be consistent without the Reactor being involved in the final predicate. In reading time studies, the integration of the congruent ending requires subjects to check whether the predicate is consistent with the Initiator as a cause ; the integration of incongruent endings requires them to check that the predicate is consistent not only with the Reactor but also with the Initiator as the implicit cause of the reaction of the Reactor. Of course, the same double constraint would apply when the subjects have to imagine incongruent endings in our paradigm.

This proposal can be explored by examining the continuations in our three experiments. We counted the explicit references to the Initiator in the incongruent continuations and the explicit references to the Reactor in the congruent continuations for the three experiments. These explicit references had to be made by pronouns or repeated nouns. Table 4 reports the percentages of explicit references to the alternative character in the continuations written in the three experiments.

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Table 4 here

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For Experiments 1a and 1b, the percentage of references to the alternative character was greater in incongruent endings than in congruent endings (Exp. 1a:  $t_1(19) = 4.8$ ,  $p < .01$ ;  $t_2(31) = 2.99$ ,  $p <$

.01; Exp. 1b:  $t_1(19) = 6.5$ ,  $p < .01$   $t_2(31) = 3.3$ ,  $p < .01$  ). Although the same numerical trend occurred in the Experiment 2, the effect was not significant, ( $t_1(23) = 1.67$ ,  $p > .1$ ;  $t_2(23) = 1.71$ ,  $.05 < p < .1$  ). This suggests that imagining a consistent incongruent ending often requires that we consider the Initiator, and that this trend to consider the alternative character is less important when the ending is congruent. In their seminal paper, Garvey and Caramazza (1974, p. 463) noticed that a way to make an incongruent causal clause consistent is to use an explicit reference to the Initiator in the predicate, although they did not report any statistics to support this intuition.

We agree with an important aspect of McKoon's analysis -- that processing a causal property consistent with the Reactor requires an additional constraint relative to processing a causal property consistent to the Initiator. We disagree with McKoon inasmuch as this does not require the Initiator to be more accessible than the Reactor before the predicate of the final clause is processed. Indeed, when congruent and incongruent endings are present in the verbal material, both characters can be relevant to integrating the final predicate. The factor considered in our discussion should deserve more attention in future works about the implicit causality, although we acknowledge that a full account of the issue require more extensive theorizing.

Our results show that the Focusing theory is a too simple way to explain the causality bias of some verbs. The bias observed for the choice of a referent in continuation tasks appears to reflect the difficulty in finding a consistent reason or motive explaining why one of the referents could be a cause of the previous event. This difficulty is independent of the level of activation of both referents before the pronoun is perceived and could be related to the number of constraints that an incongruent ending must satisfy to be consistent.

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Figure 1: Tablet surface (The active zone in gray is the part of the tablet surface which can detect the position of the stylus). The "departure square" is in black color. The second square (in white color) was the zone of the tablet where the subject posed the pen after reading the fragment. (Black triangles represent four supports maintaining the position of the sheet).

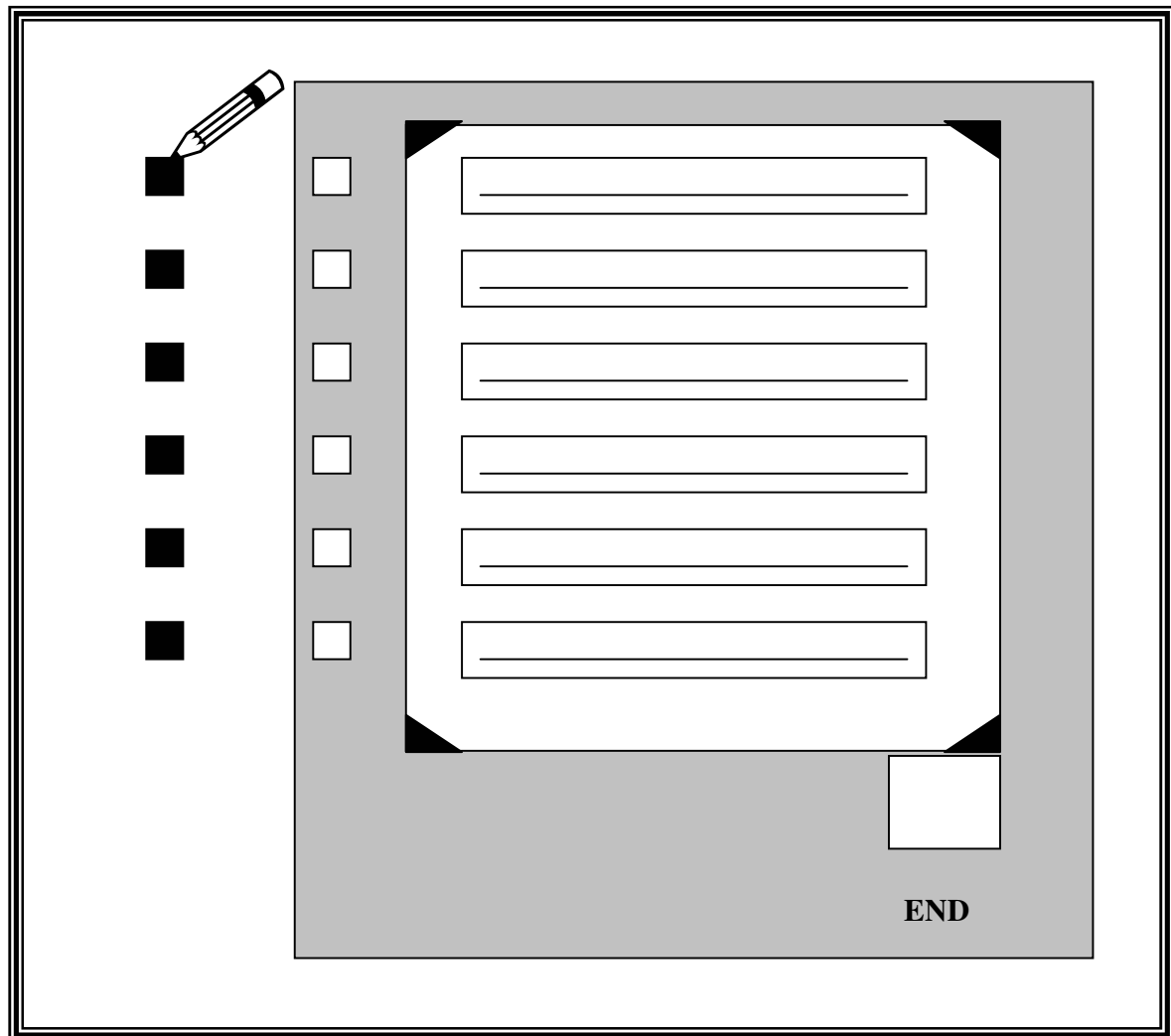


Table 1. Mean reading times (ms) of the fragment to continue in Experiment 1a. Standard deviations are given in parentheses.

Verbal bias	Pronoun		overall mean
	Congruent	Incongruent	
N1	6,261 (1,947)	6,385 (2,071)	6,323
N2	5,602 (1,798)	5,682 (1,742)	5,642
overall mean	5,931	6,033	



Table 2. Mean planning times (ms) in Experiments 1a and 1b. Standard deviations are given in parentheses.

Pronoun			
Experiment 1a (self-paced presentation of the fragment to continue)			
Verbal bias	Congruent	Incongruent	overall mean
N1	6,248 (3,285)	8,565 (4,351)	7,406
N2	5,462 (3,244)	6,442 (2,934)	5,952
overall mean	5,855	7,503	
Experiment 1b (RSVP of the fragment to continue)			
Verbal bias	Congruent	Incongruent	overall mean
N1	4,468 (2,134)	5,763 (2,458)	5,115
N2	3,979 (2,054)	4,852 (2,322)	4,415
overall mean	4,223	5,307	

Table 3. Mean naming latencies and mean planning times (ms) in Experiment 2. Standard deviations are given in parentheses.

	Congruent	Incongruent	External
Naming latency	560 (77)	558 (80)	603 (89)
Planning time	10,174 (6,713)	13,668 (8,230)	15,158 (8,529)

Table 4. Mean percentages of explicit references to the alternative character in the congruent and incongruent continuations written by the subjects in Experiments 1a, 1b, and 2. Standard deviations are given in parentheses. The exact proportions are indicated between squared brackets.

	Congruent (references to the Reactor)	Incongruent (references to the Initiator)
Experiment 1a	33.1% [212/640] (14.4)	50.0% [320/640] (15.9)
Experiment 1b	36.2% [232/640] (13.4)	54.7% [350/640] (15.1)
Experiment 2	27.6% [53/192] (17.3)	35.9% [69/192] (17.8)